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United States Department of the Interior

GEOLOGICAL SURVEY

RM. 237 - 515 9th St.
Rapid City, South Dakota 57701
June 10,1988

Mr. John Wilbanks
Brohm Mining Corp.
P.O. Box 485
Deadwood, SD 57732

Dear Mr. Wilbanks:

As per our telephone conversation, please find enclosed a copy of the Northern Hills Hydrology Study for your information.

FOR THE SUBDISTRICT CHIEF

Earl A. Greene

Earl A. Greene
Hydrologist

WATER RESOURCES APPRAISAL OF THE NORTHERN BLACK HILLS, SD, WITH EMPHASIS ON THE EFFECTS OF RESOURCE DEVELOPMENT

Problem

The Black Hills area of South Dakota is without a regional hydrology study to characterize and describe fundamental information on quantity and quality of the surface and ground-water resources. The Black Hills area is experiencing an expansion of mining activity, urbanization, and recreational activity. There is concern about the potential for this development to effect the quantity and quality of the surface and ground-water of the Black Hills.

This study needs to specifically address: 1) the lack of baseline information on water quantity and quality throughout the Hills; 2) the bedrock aquifers and the ground-water and surface-water interaction; and 3) the lack of information available to predict effects of resource development on the water resources of the Black Hills.

Several agencies have agreed to cooperate and work towards a regional hydrologic study that will address these stated information needs. They are: Lawrence County, the State of South Dakota, West Dakota Water Development District, Black Hills Council of Local Governments, and the U.S. Geological Survey. The regional study will begin this fiscal year in the northern Black Hills and expand to the remainder of the Black Hills as time and funding progresses.

All work initiated in FY88 will be designed and conducted so that the data will be incorporated into the larger regional study when the work plan is developed later this fiscal year.

Background

The northern Black Hills area, consisting mainly of Lawrence County, is situated in western South Dakota along the northeastern slopes of the Black Hills (figure 1). The County's unique and varied geology has created areas of unusual scenic beauty along with economic deposits of various minerals, particularly gold.

Development of the County's resources has propagated many land uses and industries. Mining, urbanization, timber harvest, tourism, outdoor recreation, and agriculture as some of these uses, many which are in direct conflict with each other.

The hydrology of the northern Black Hills area is complex due to wide variations in climate, geology, topography, land use, and ownership patterns. For example, the surface geology west of Spearfish Creek consists mainly of limestone of the Madison

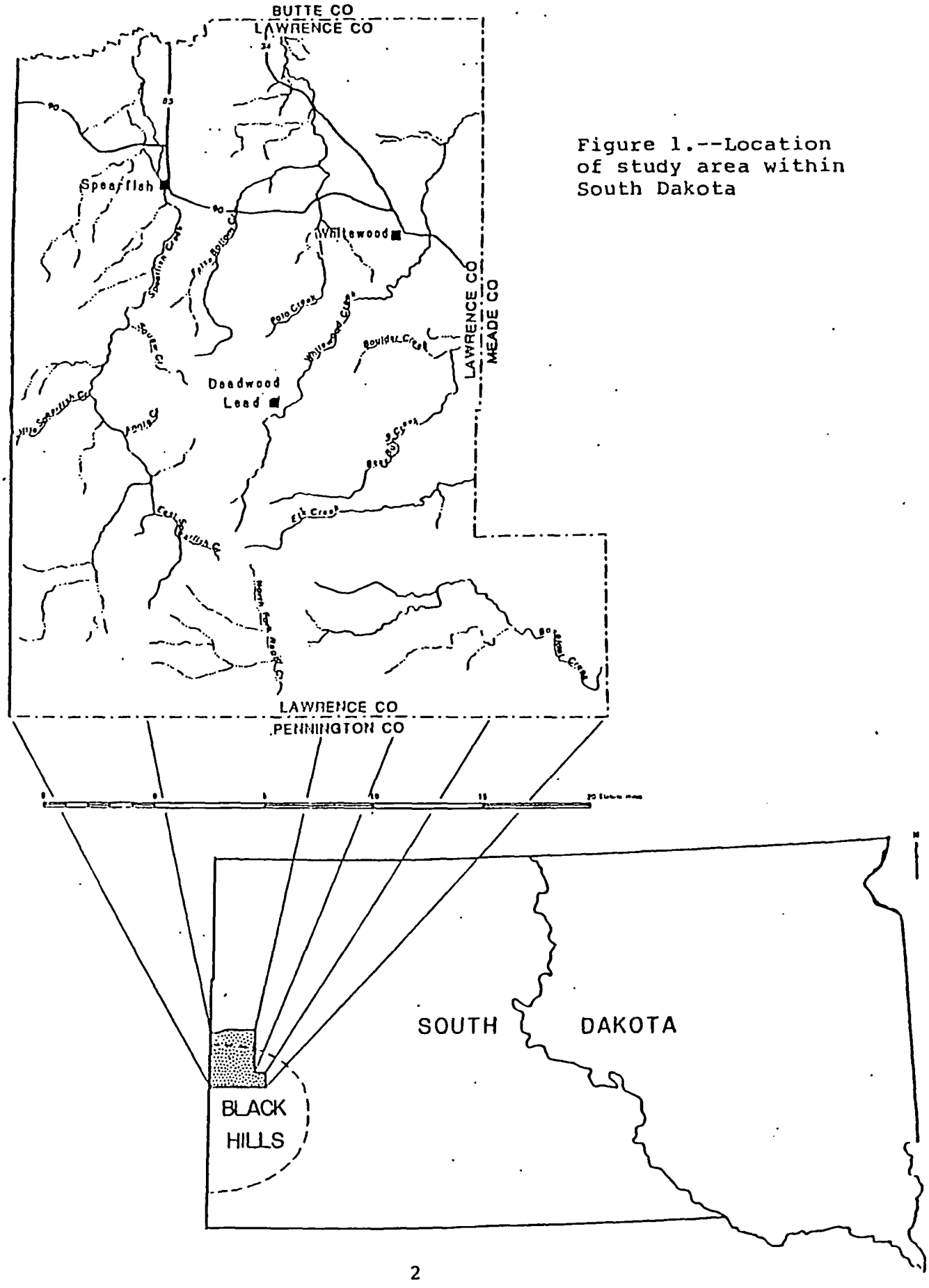

Figure 1.--Location of study area within South Dakota

Formation. Whereas, the eastern part of the study area contains large areas of metamorphic and igneous intrusive rocks where most of the mineral enrichment has occurred. In the limestone areas, large carbonate springs and disappearing streams are prevalent. All of these factors combine to complicate the hydrology of the area.

The 512,000 acres within Lawrence County contain the majority of gold-bearing deposits in the Black Hills. Three active gold mines are currently operating within Lawrence County - Wharf, Homestake (North America's oldest), and Brohm. Three additional operations are proposed: St. Joe, Golden Reward and Minerva. Information on acres of pre-mine and post-mining activity is presented in Table 1 for the gold and silver surface mines in Lawrence County. The permitted acreage for various minerals within several counties of the Black Hills is presented in Table 2.

The City of Spearfish is located along Spearfish Creek in the foothills of the Black Hills (figure 1). The community secures its municipal drinking water supply from Spearfish Creek and several Madison wells. The City has expressed concern about groundwater contamination of the near surface alluvial aquifer in Spearfish Valley.

The water resources of the northern Black Hills and Lawrence County are without comprehensive study. The preponderance of previous work is either of limited geographic extent or confined to a specific topic. Darton (1909) provided the first scholarly description of the waters of the northern hills. Kyllonen and Peter (1987) and Peter et. al. (1987) have published work on the bedrock aquifers (Inyan Kara, Minnelusa, Madison) primarily in the foothills and prairie regions of the area. Goddard (1987) has intensively studied the mobility and fate of arsenic and other trace elements within the Whitewood Creek basin. Because of this existing knowledge, little additional work will be planned for the Whitewood Creek basin. Water quality samples are now being collected by the State of South Dakota and individual mining companies at 18 and 52 sites, respectively. These samples are collected for regulatory purposes for a selected list of parameters. Additional sites, parameters, and some differences in the sampling scheme will be utilized to establish baseline water quality conditions by which changes (if any) can be determined as the result of resource development.

Objectives

The objectives for a regional hydrolgic investigation are:

1. To inventory the bedrock aquifers in the northern Black Hills with emphasis on the area of Lawrence County south of Spearfish and the shallow alluvial aquifer along Spearfish Creek.

2. To study the surface waters of the northern Hills area,

Table 1.--All permitted mining operations within Butte, Custer, Lawrence, Meade, and Pennington Counties.

	Acres Permitted	% of Total	Acres Disturbed	% of Total
LIMESTONE	1,915.0	48.8	218.5	16.1
GOLD/SILVER	1,100.8	28.0	720.4	53.2
BENTONITE	560.5	14.3	324.0	23.9
SHALE	151.0	3.8	11.5	0.9
PEGMATITE	57.3	1.5	30.5	2.3
TIN, TUNGSTEN, TANTULUM	55.0	1.4	3.0	0.2
GYPSUM	48.0	1.2	45.0	3.3
IRON	40.0	1.0	1.0	0.1
TOTAL	3,927.6	100.0	1,353.9	100.0

Source: DWNR records of September 4, 1987.

Black Hills Council of Local Governments.

Table 2.--Information on large scale gold/silver mining activity within Lawrence County.

	Acres permitted (or expected)	Total Mining Disturbance thru 9/1/87	Acres Reclaimed thru 9/1/87
ACTIVE OPERATING PERMITS: (Three (Wharf; Homestake; Brohm)	998.3	702*	116
PERMIT APPLICATION SUBMITTED: One (St. Joe)	(363.4)	n/a	n/a
PROPOSED OPERATIONS: Two (Golden Reward; Minerva)	(900.0)	n/a	n/a
TOTAL	2,261.7	702	116

* Includes 100 acres of premining activity at Brohm's Gilt Edge Mine.

Source: DWNR records as of September 4, 1987

Black Hills Council of Local Government

This will involve:

a. an inventory of the springs, lakes and streams,

b. and the establishment of a long-term streamflow monitoring program at sites where data is lacking and where resource conflicts are anticipated.

3. To determine existing water-quality conditions of both ground-waters and surface-waters at selected sites within the County.

The specific objectives for FY88 are:

4. To establish a streamflow, precipitation and water quality monitoring network.

5. Obtain geophysical logs from selected wells drilled for individual landowners, mining companies, and for other government agencies.

6. Collect and analyze water samples collected at selected sites within the northern Hills area.

7. Prepare the final proposal and plan of study for regional hydrologic investigations.

General Approach

The general approach for this plan of study are presented below.

A ground-water inventory (Objective 1) will be conducted by the collection and analysis of existing data and obtaining geophysical logs from wells drilled by others. In general, this objective would be accomplished by inventorying existing wells to obtain information on aquifer locations, extent, depth, thickness, ground-water levels, water quality, character of the aquifer, locations of potential ground-water contamination sites, and geologic constraints to ground-water movement. An attempt will be made to inventory and catalog all wells within the County. Borehole geophysics will be used to evaluate the lithology and geologic structure of the aquifers. It is anticipated that selected wells drilled by mining companies will be available for data collection.

The surface-water resources of Lawrence County (Objective 2) will be studied by field inventory and measurement of the lakes, streams and springs. In addition, a network of precipitation and streamflow gages will be installed to establish a long-term monitoring program (see next section).

The existing water-quality conditions (Objective 3) will be defined by examining existing data and gathering additional samples from selected wells and streams. More detail on the sampling scheme will be provided in the plan of study.

Ground-water quality data will be obtained in conjunction with the well inventory. Field measurements of temperature, conductivity, and pH will be made from wells that allow representative samples to be obtained. At wells where contamination from septic tank effluent is possible, field tests for fecal coliform bacteria will be made and water samples for nitrate nitrogen analysis will be collected. At wells representative of specific geologic units, water samples for major ions and trace elements (Table 4) will be obtained and analyzed.

Surface-water quality data will be collected quarterly from all significant streams in Lawrence County. Names and locations of proposed surface-water sampling sites are listed on Table 3 and 5. Field measurements of temperature, conductivity, pH, dissolved oxygen, and fecal coliform bacteria will be made and water samples for determination of major ions, nutrients, and trace elements (Table 4) will be collected. Water samples will be analyzed by the U.S. Geological Survey National Water Quality Laboratory (NWQL) in Arvada, Colorado or at another laboratory with a Survey approved quality assurance plan.

Much of the information required to define the impact of historical mining activities is presently available from previous and ongoing studies. New surface mines are now or will soon be operating in Annie, Squaw, and Bear Butte basins.
These new areas recently opened to mining will be monitored.

Activities for FY88

A network of precipitation and streamflow gages will be installed to establish a long-term monitoring program. Eight continuous streamflow gages will be constructed at the locations given in Figure 2 and Table 3. About 10 non-recording precipitation gages will be installed in a manner to achieve a spatial distribution throughout the northern Hills.

A network of water quality sampling stations will be established as shown in Figure 2 , Table 3, and Table 5. Two site visits are planned for each site in FY88 to collect water samples to be analyzed for the parameters listed in Table 4. Two streamflow gaging sites, Annie Creek and Squaw Creek below Maurice, will be equipped with continuous recorders to monitor water temperature, specific conductance, pH, and discharge, and possibly dissolved oxygen and Eh.

Borehole geophysical logs will be obtained from wells and test holes drilled in the northern Hills area. Only selected holes that will produce a spatial distribution will be logged among the hundreds of wells and holes to be drilled by various entities this fiscal year.

Also planned for this fiscal year is the planning, coordination, and writing of a detailed plan of study for a more comprehensive regional hydrologic study.

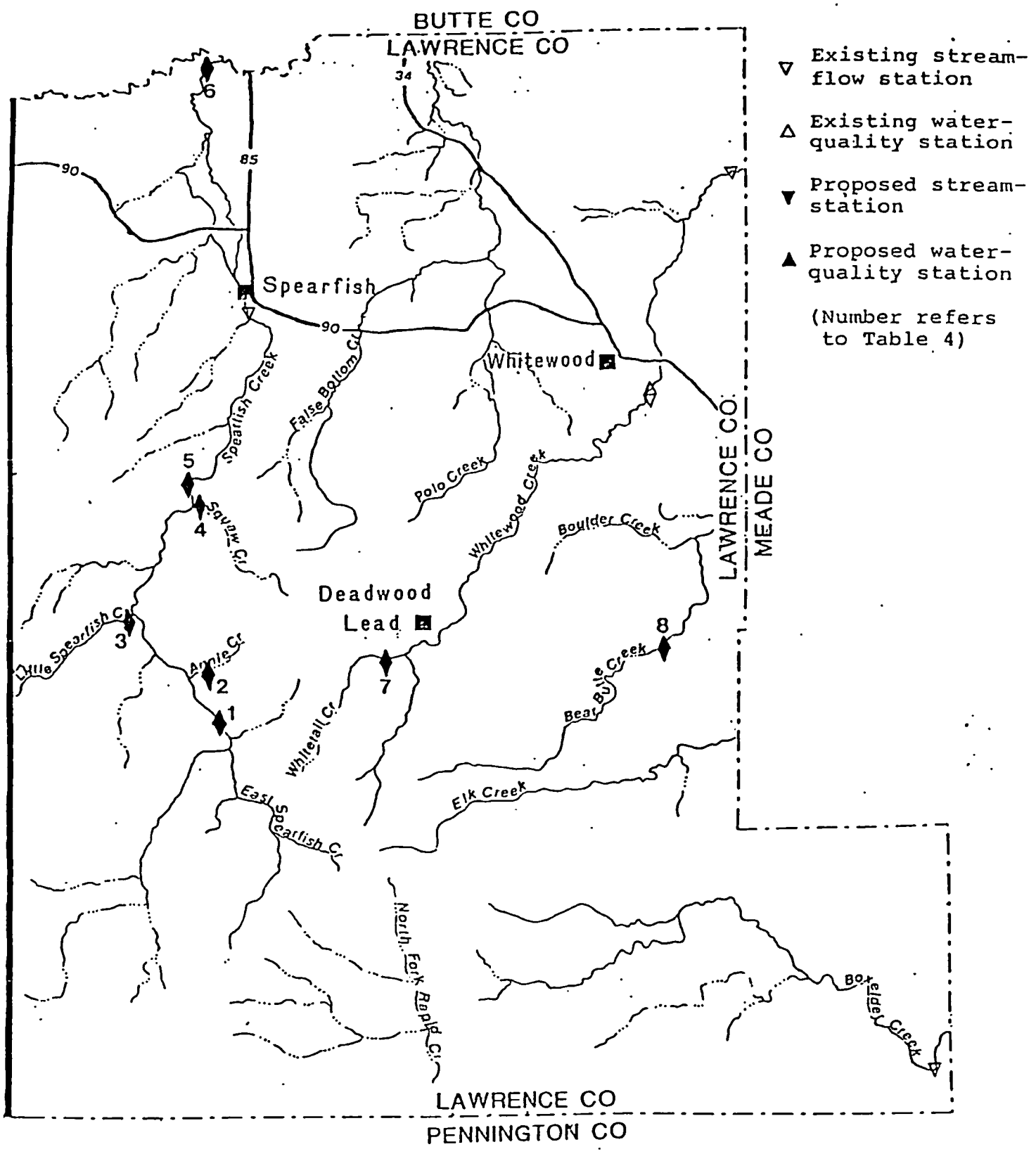

Figure 2. --Existing and proposed streamflow and water-quality stations in Lawrence County.

Table 3.--Continuous streamflow gaging stations proposed for construction in FY88 in the northern Black Hills, SD

Site Number a/	Station Description	Location T R S	FY88 Priority b/
1	Spearfish Creek below Cheyenne Crossing, SD	4N,2E,15,SW1/4	2
2	Annie Cr. below Cheyenne Crossing, SD	4N,2E, 9,NW1/4	1
3	Little Spearfish Cr. above Savoy, SD	5N,1E,36,SE1/4	2
4	Squaw Creek below Maurice, SD	5N,2E,17,NE1/4	1
5	Spearfish Creek below Maurice, SD	5N,2E,17,NE1/4	1
6	Spearfish Creek below Spearfish, SD	7N,2E, 9,NW1/4	1
7	Whitetail Creek above Lead, SD	4N,3E, 5,SW1/4	1
8	Bear Butte Creek below Galena near Lead, SD	4N,4E, 3,W1/2	1

a) from Figure 2.

b) Priority and order of construction in FY88. (1 is high priority)

Table 4.--Constituents to be determined by laboratory analysis at the U. S. Geological Survey National Water Quality Laboratory.

Major Ions

Calcium
Magnesium
Potassium
Sodium
Alkalinity
Sulfate
Chloride
Fluroide

Total dissolved solids, @ 105 C

Total Suspended Solids

Nutrients

Nitrogen, ammonia plus organic
Nitrogen, nitrite plus nitrate
Phosphorus

Trace Elements

Antimony
Arsenic
Barium
Cadmium
Chromium
Copper
Iron
Lead
Manganese
Mercury
Silicon
Zinc

Other

Cyanide
Radium
Gross Alpha

Table 5.--Water Quality [a/] and Instantaneous Streamflow gaging stations proposed for sampling in the Northern Hills, SD for FY88

Site Descriptions	Location T R S	Water Quality Sampling
False Bottom Creek near Deadwood, SD	5N,2E,13,NE1/4	yes
False Bottom Creek near Spearfish, SD	6N,3E,18,SE1/4	yes
Iron Creek below Savoy, SD	5N,2E,30,NW1/4	yes
Long Valley Creek above Maurice,SD	5N,2E,19,NE1/4	yes
Spearfish Creek at City of Spearfish Intake below Maurice, SD	5N,2E, 8, E1/2	yes

a/ All sites listed in Table 3 will be sampled as water quality stations during FY88.

Final Products

The project will provide several final products. First, the streamflow data will be published within the U.S. Geological Survey's Water Data Reports. Second, the well data will be compiled into a data report and possibly onto a IBM PC computer disk for the direct use of the Cooperators. Third, a final report will summarize the results of the entire project. It is anticipated that the final report will be published as Water Resources Investigations Report.

Funding

The project will be funded jointly by Lawrence County, the State of South Dakota and the U.S. Geological Survey. Project funds available in FY88 total $120,000.

The U.S. Geological Survey will contribute 50% of the funding with the remaining 50% contributed by the State and the County. See Table 6 for the FY88 budget.

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